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ABSTRACT

This volume contains outlines for 16 courses in machine theory that are designed for machine tool apprentices. Addressed in the individual course outlines are the following topics: basic concepts; lathes; milling machines; drills, saws, and shapers; heat treatment and metallurgy; grinders; quality control; hydraulics and pneumatics; electro-discharge machines; numerical control; dies and their design; eyelets; screw machines; mold construction; bore mills; and jig borers and grinders. Each outline includes a unit objective. Concluding the guide is a list of recommended texts designed to serve as basic course texts or to supplement the basic course texts and brief descriptions of the contents of this series of courses as well as of the contents of two other series of courses--on math and blueprint reading--that are also designed for machine tool apprentices. (MN)

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APPRENTICE MACHINE THEORY OUTLINE

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APPRENTICE OUTLINE - MACHINE THEORY

T-1 BASIC PRINCIPLES

OBJECTIVE: To provide the student with the basic principle of the Machine Trades as related to the bench work.

I. ORIENTATION - Problems pertinent to local situation.

A. What is the Machine Tool Industry?

B. History

C. Importance: economy, etc.

II. GENERAL SHOP SAFETY

A. Evye

B. Moving parts, guards

C. Clothing and hair

D. Cutters and grinding wheels

E. Safe work holding practices

III. OCCUPATIONAL HEALTH AND SAFETY ACT (OSHA)

A. Purpose

B. Guarding devices

C. Safe handling of:

1. Cutting tools

2. Grinding wheels

D. Personal Protection

1. Eyes

2. Clothing

3. Face and hair

4. Respiratory

E. Fire Protection

1. Maintain extinguishers

2. Safety cans and containers

3. Wire electrical connections

4. Fire alarm systems

III. OCCUPATIONAL HEALTH AND SAFETY ACT (OSHA) (Continued)

f. Shop Areas

1. Housekeeping

a. Clear aisles, stairs, etc.

b. Floor clear

c. Doors clear

2. Ladders - safe use of

G. Safety Color Coding

1. Purposes of colors

a. Red

b. Orange

c. Yellow

d. Green

e. Blue

f. Purple

g. Black and White

IV. HANDTOOLS

A. Use and care

B. Hammers

C. Screwdrivers

D. Safety for hammers and screwdrivers

Test -Hammers and screwdrivers

E. Wrenches and their use

F. Hacksaws and their use

G. Power saws

H. Safety using wrenches, hacksaws and power saws

V. MEASUREMENT AND MEASURING TOOLS

A. The Steel Rule

1. Types (fractions - decimals)

2. Gradations

3. Apply fraction (addition, subtraction and division)

4. Metric measurement

B. The Micrometer

1. Nomenclature, care and types

2. Gradations

3. Apply decimals (addition, subtraction and division)

C. Protractor

1. Types of nomenclature

2. Application of the circle (Degrees and minutes)

3. Angular measure (complementary and supplementary angles)

D. Indicators

1. Types and care of

2. Dial .001 gradations

3. Dial gages

E. Miscellaneous - Small Tools

1. Inside, outside and hermaphrodite calipers

2. Screw pitch gage

3. Drill gages (all types)

4. Square (combination, etc.)

5. Surface gage

6. Center gage

F. Principles of the Vernier Scale

1. Application to:

a. Height gages

b. Calipers

c. Machine positioning dial

d. Protractor

e. Rotary table

f. Review angular measures

V. MECHANICAL MOVEMENTS AND DEVICES

A. Lever

B. Pulley

C. Inclined plane

D. Wheel and axle

E. Wedge

F. Screw

VI. BENCH WORK

A. Safety

B. Hand Tools

1. Files - types and safe practices
2. Electric hand tools - safe practices
3. Hacksaws, punches, scriber, etc. - safe practices
4. Adjustable wrench, spanner, box and solid - safe practices

C. Layout

1. Preparation of surfaces
   a. Blueing
   b. Red
   c. Chalk
   d. Oxidizing (head)

D. Taps and Dies

1. Types
2. Clearances and rakes
3. method of sharpening
4. Surface speeds
5. Coolants
6. Degree of accuracy
7. Causes of tap breakage

F. Screws

1. Types of screws
2. Classified by type of head
3. Classified by pitch
4. Class of fit

G. Pins and Keyways

1. Dowel, soft and hardened
2. Purpose
3. Method of application
4. Taper pins
5. Size specificiations by number and length
6. Methods of application
7. Types of keys, etc.

APPRENTICE OUTLINE - MACHINE THEORY

T-2 LATHE

OBJECTIVE: To provide the student with the information related to the theory and application of the lathe

I. SAFETY

II. LATHE -TOOL ROOM

A. Orientation

1. Nomenclature, types, sizes
2. Maintenance

B. Frictions and Lubrication

1. Centers
2. Ways
3. Moving parts

C. Methods of Mounting Work

1. Centers (centering stock)
2. Chucking (collets, 3 and 4 jaw chucks)
3. Turning, boring and facing operations
4. Drilling, reaming and tapping operations
5. Knurling and thread operations (external)
6. Cut off stock
7. True work in chuck (indicator, chalk, etc.)

D. Attachments(set-up procedures and functions)

1. Taper (3 methods)
2. Steady rests
3. Tool post grinder

4. Tapers

a. Types

b. Calculating tapers (ft./in.)

c. Handbook and tables

d. Tapered reamers, Jarno, B & S, Morse, etc.

E. Speeds and Feeds

F. Lubrication

G. Boring and Cutting Internal threads

H. Truing Soft Jaws

III. LATHE-TRACER

A. Safety

B. Tracer Lathe Types

1. Electic

2. Hydraulic

3. Accessories

4. Principles of Operation

C. Work Mounting Techniques

1. Chucks

a. 3 Jaw

b. 4 Jaw

c. Soft Saw

2. Collets

a. Draw bar

b. Speed

c. Rubber

3. Centers
    a. Dead
    b. Live
    c. Half

D. Stylus
    1. Mounting
    2. Forms, Radii
    3. Relation to cutting tool

E. Setting Tool Slides
    1. Angle of setting
    2. Aligning templates
    3. Mounting template (relation to workpiece)

F. Setting Cutting Tools
    1. Cutting edges on tool
    2. Cutting tool location on workpiece

G. Positioning Tracing Arm
    1. Relationship to template
    2. Relationship to stylus
    3. Clamping tracer arm
    4. Positioning and adjusting stylus
    5. Trail cuts

H. Templates
    1. Select template materials
    2. Layout templates
    3. Selection of feeds and speeds

I. Turning Eccentrics

J. Form Tool Work

K. Cool Cuts

1. Purposes of

a. Cooling

b. Chip carrying

c. Reduction of friction

2. Types

L. Face Plate Work Technique

M. Machinability of Metals

IV. THREADS AND THREADING

A. Thread Forms and Types

1. Unified and U.S. Standard (60^{o})

a. Pitch of thread (apply formula)

b. Lead of thread

c. Major diameter and minor diameter (apply formula)

d. Compund rest setting (apply formula)

e. Classify types of fits

f. Set up

2. Acme

3. Square

4. Multiple lead

B. Thread Nomenclature and Measurement

1. Thread series
2. Helix angle
3. Pitch diameter (apply formula)
4. Crest (apply formula)
5. Root (apply formula)
6. Use of handbook and tables
7. Thread micrometers, gages, three wire systems and comparators

C. Thread Cutting (types of machines)

1. Thread series (4-40 - 5-40, etc.)
2. Tapping
   a. Selection of tap drill
3. Chasing with die
   a. Adjust die
4. Lathe
   a. Gear box setting (chart on box setting)
5. Other thread cutting equipment

V. STANDARD MACHINE TAPERS

A. Morse

B. Jarno

C. Special

D. Methods of cutting

E. Problems in turning

F. B. & S. Taper

G. Standard Milling Machine Taper

APPRENTICE OUTLINE - MACHINE THEORY

T-3 MILLING

OBJECTIVE: This course is designed to provide the student with information which will enable him to set up and operate milling machines.

I. SAFETY

II. MILLING MACHINE

A. Principles of milling machine operations

1. Work fixed
2. Cutter rotates

B. Types

1. Vertical
2. Plain
3. Universal
4. Jig Bore
5. Jig Grinder
6. Drilling and Boring

C. Setups and Operations

1. Methods of alignment
2. Setting the machine and milling operations
3. Clamping and holding the work

D. Milling Processes

1. Climb and conventional
2. Horizontal, vertical
3. Drilling, boring, reaming and tapping
4. Speeds and feeds

a. Tooth loads

5. Straddle and gang milling

6. Truing table and mounting devices

7. Tram spindle to table

8. Locate edges

9. Mill against solid jaw, etc.

E. Work Holding Devices

1. Vises

2. Fixtures

3. Strapping

4. Rotary table

5. Angle plate work

6. "V" block work

F. Dividing Head

1. Direct indexing

2. Simple indexing

a. Formula $T = \frac{40}{N}$

b. Plate selection

c. Use of handbooks and tables

d. Angle indexing (degrees, minutes)

III. SPUR GEAR TERMINOLOGY AND FORMULAS

A. Terminology

1. Explanation of gear terms

B. Different kinds of Common Gears

1. Spur

2. Bevel

3. Worm

4. Spiral

5. Sprockets

C. Functioning of Gears

D. Rules and formulas for dimension of spur gears

E. Rules and forumlas for dimensioning bevel gears

F. Rules -- worm gears

G. Rules -- spiral gears

H. Rules -- sprockets

I. Methods used in manufacturing gears

J. Materials commonly used for making gears

K. Inspection methods

IV. <u>IRREGULAR SHAPES: CAMS AND CAM ACTION</u>

A. Principles and Types

B. Application

C. Cutting Cams

APPRENTICE OUTLINE - MACHINE THEORY

T-4 DRILL, SAWS, SHAPERS, AND CUTTING TOOLS

OBJECTIVE: To provide the student with knowledge of the operation and uses of drills, saws, sharpers, and cutting tools.

I. SAFETY

II. DRILLS AND DRILLING

- A. Holding devices and clamping
- B. Parts of the drill and their functions
- C. Types of drills
- D. Principles of sharpening a drill
- E. Speeds and feeds
- F. Cutting oils and coolants
- G. Drilling holes
- H. Safety on the drill press

III. DRILL PRESS

- A. Drill press construction
- B. Types

IV. BAND SAWS

- A. Types
  - 1. Horizontal
  - 2. Vertical
  - 3. Nomenclature
- B. Blade Selection
  - 1. Materials
  - 2. Speeds and Feeds

3. Cutting action

a. Set of teeth

b. Friction cutting

c. Types of blades

4. Effects of numbers of teeth

5. Mounting blades

6. Work holding and cutting techniques

7. Weld blades

8. Set saw guides

V. SHAPER

A. Principles of Shaper Operation

1. Types

2. Nomenclature

3. Work holding techniques

4. Uses for and tool Clearances

VI. CUTTING TOOLS

1. SINGLE POINT CUTTING TOOLS

A. Characteristics (hardening)

B. Clearances for cutting edge (angles)

C. Chip control

D. Shapes of tools

1. Turning, facing, threading

2. necking (cut off)

3. Shaping

2. TYPES OF CUTTING TOOL MATERIALS

   A. H.S.S.

   B. Carbide

   C. Ceramic

   D. Cobalt

   E. Alloys, etc.

3. COOLANTS AND LUBRICANTS

4. CUTTING ANGLES AND PRINCIPLES

   A. Side cutting edge angle

   B. Rake angles

   C. Chip breakers

5. FEEDS AND SPEEDS; COMPUTATIONS FOR:

   A. Milling cutters

   B. Turning tools

   C. Drilling, reaming, c' boring, etc.

   D. Grinding

   E. Tapping

   F. Saws

   G. Form tools and broaches

6. FORM TOOLS

   A. Radius tools

   B. Irregular and special shapes

7. MILLING CUTTERS

   A. Safety

B. Review of concepts of cutting

C. Types of cutters, face milling, form and angle milling and slitting saws, etc.

D. Principles of mounting cutters

E. Single and multiple lip end mills

APPRENTICE OUTLINE - MACHINE THEORY

T-5 METALLURGY AND HEAT TREATING

OBJECTIVE: To provide the student with the knowledge of materials, process for surface finishes and processes which change physical properties of metals.

I. SAFETY

II. BASIC METALLURGY

A. Definition and scope, introduction to metals

B. Atoms and their behavior

C. Properties of metals

D. Coding systems

E. Basic metals

1. Ferrous

2. Non-ferrous

F. Production of iron and steel

G. Chemical nature of steel

1. Iron carbon diagram

2. Low, medium and high carbon content

H. Surface treatment of metals

1. Heat treatment

2. Cold working

I. Alloys

1. Types (of H.S.S.)

2. Effects of alloying

J. S.A.E. Standards

K. Non-ferrous metals

III. Heat Treatment

A. Safety

B. Hardening

C. Tempering

D. Critical temperatures

E. Case hardening

F. Pack hardening

G. Annealing

H. Hardness testing

I. Relation of hardness to other physical properties

J. Non-ferrous metals

APPRENTICE OUTLINE - machine theory

T-6 GRINDING

OBJECTIVE: To provide the student with the knowledge of the Grinding Processes.

I. SAFETY

II. GRINDING AND MACHINE CONSTRUCTION

A. Grinding operations in industry

B. Types

1. Pedestal
2. Surface
3. O.D. and I.D.
4. Tool and cutter
5. Hand grinders

C. Grinding terms

III. GRINDING

A. Composition of wheels

1. Dressing wheels (basic)
2. Selection (types)
3. Coding
4. Abrasives and bonds
5. Mounting and dressing tecniques
6. Work holding devices
7. Testing of wheels
8. Speeds and feeds
9. Precaution measures

B. Grinding angles and work mounting techniques

1. Sine bar

2. Wheel forming

3. Cut off wheels

4. Plunge grinding

C. Coolants

D. Tool and cutter grinding

1. Types

2. Mounting wheels

3. Truing and dressing wheels

4. Setting up cutters

a. Plain

b. Stagger tooth

c. Slab mills

d. Angle cutters

e. Cutter angles and clearances

f. Gages

g. Single lip

E. Surface finishes

1. Micro-finishes

2. Effects of wheel selection

3. Effects of heat

F. Types and Maintenance

1. Surface
2. O.D. and I.D. cylindrical grinding
3. Cutter
4. Special
5. Oiling, emery dust, etc.
6. lap and hon

G. Causes of inaccurate work and imperfect appearance

APPRENTICE OUTLINE - MACHINE THEORY

T-7 QUALITY CONTROL

OBJECTIVE: To provide the apprentice with information to enable him/her to process jobs with minimal error.

I. JOB PROCESSING, PRINCIPLES

- A. Selection of material
- B. Locations
- C. Sequence
- D. Tools and equipment
- E. Accumulation of tolerances
- F. Tolerance charts
- G. Sketches
- H. Inspection

II. INSPECTION

- A. Principles of linear measurements
  - 1. English system
  - 2. Metric system
- B. Standards for measurements
  - 1. History of the international bureau of weights & measurements
- C. Interchangeability
  - 1. Dimension limits
  - 2. Tolerance
  - 3. Allowance

D. Gages

1. Plain ring gage
2. Taper ring gage
3. Thread ring gage
4. Plain cylindrical plug gage
5. Cylindrical - taper plug gage
6. Thread plug gage
7. Roll-thread snap gage

E. Dial test-indicator gages

1. Balanced type dial gage
2. Continuous-reading dial gage
3. Dial-indicating depth gages
4. Dial-indicating snap gages
5. Dial comparators

F. Telescoping gage

1. Small-hole gage

G. Gage Blocks

1. Classification
2. Assembling
3. Building combinations
4. Effects of temperature and dust
5. Review of decimals

H. Surface Plate

1. Types of plates
2. Accuracy
3. Care of plates

I. Surface Plate Work

1. Checking for parallelism
2. Measuring the location of holes
3. Concentricity, T.I.R. and coaxiality
4. Measuring angles and tapers
5. Formulas for calculating angles

J. Surface Gage Work

1. Checking for squareness
2. Checking for roundness

K. Special Gages

1. "Go" and NO Go" gages (also thread)
2. Ring gages
3. Taper gages
4. Thread measurement
5. Adjustable parallels
6. Hardness tester
7. Electro-limit gages

L. Cutter Clearance Gages

M. Comparator

1. Principles of
2. Purpose
3. Lenses and their use

N. Sine Bar

1. Principles

2. Types (5" - 10", Sine plate)

3. Use of trig tables and handbook

4. Set-up for angles (p]laner gage, angle plate and size blocks)

5. Compund angle settings and problems

APPRENTICE OUTLINE - MACHINE THEORY

T-8 HYDRAULICS

OBJECTIVE: To provide the student with a basic knowledge of hydraulic systems and their application to machine tools.

I. SAFETY

A. Care in dealing with

1. High pressures

2. Tremendous forces

II. ADVANTAGES OF HYDRAULICS

A. Large forces created with little power

B. Infinite speed control (within system limits)

C. Uniform motion

III. Principles of hydraulics

A. Force = (presure) (area)

IV. HYDRAULIC COMPONENTS

A. Pumps

1. Positive displacement (gear, piston)

2. Variable displacement (vane, piston)

B. Reservoirs

C. Filters

D. Valves

1. Directional control

a. Operators

b. Purpose (2,3,4 way)

2. Relief

3. Pressure control

4. Flow control

5. Check

E. Actuators

1. Cylinders (reciprocation)

2. Rotary (Oscillation)

V. USES IN MACHINE TOOLS

A. Presses

B. Table feeds

APPRENTICE OUTLINE - MACHINE THEORY

T-9 ELECTRO-DISCHARGE MACHINE (EDM)

OBJECTIVE: To provide the student with the knowledge of electro-discharge machining and its application and use in machine tooling.

I. SAFETY

II. PRINCIPLES AND ADVANTAGES

III. FUNCTION OF EDM

- A. Types of EDM
- B. Operation of machine

IV. SET UP TECHNIQUES AND WORK HOLDING DEVICES

- A. Flushing techniques
- B. Accessories and their uses

V. ELECTRODE MATERIALS

- A. Carbon
- B. Copper
- C. Others
- D. Surface finishes
- E. Making electodes for EDM
- F. Calculating overcut, wear, stock removal, wear ration
- G. Methods of 2 dimensional electrode construction
- H. Duplicating from template and layout
- I. Methods of 3 dimensional electrode construction

IV. DUPLICATING FROM MODELS, SAMPLE PART, MOLD

A. Types of duplicating machine tools 2D and 3D, hand - hydraulically operated

B. Operation of equipment

C. Selection of cutters

1. Ball mill

2. Single lip

3. Carbide burs

D. Speeds and feeds

APPRENTICE OUTLINE - MACHINE THEORY

T-10 NUMERICAL CONTROL

OBJECTIVE: To provide the student with the knowledge of numerical control systems and their application and use.

I. INTRODUCTION TO NUMBERICAL CONTROL

- A. Definition of numerical control
- B. History of numerical control
  - 1. Early automatic controls
  - 2. Development of numerical controls
- C. Objectives of numerical control

II. APPLICATIONS OF NUMERICAL CONTROL

- A. Types of N/C control systems
  - 1. Point to point
  - 2. Continuous path
- B. Industries that utilize N/C and their applications
- C. Advantages and disadvantages of N/C
- D. Open and close loop control systems
- E. Types of servo mechanisms
- F. Basic process flow of numerical control

III. DIMENSIONING SYSTEMS AND AXIS DESIGNATION

- A. Cartesian coordinate system
- B. Axis nomenclature
- C. Right hand coordinate rule

D. Types of numerical control dimensioning systems

1. Absolute system

2. Incremental system

3. Base line system

IV. TAPE CODES AND FORMATS

A. EIA tape standards

B. Types of tape materials

1. Paper

2. Mylar

3. Magnetic

C. Binary coded decimal and numbering systems

D. American standard code for information interchange

E. Types of tape readers

1. Mechanical

2. Prematic

3. Photo-electric

4. Magnetic

F. Types of tape format

1. Fixed block format

2. Fixed sequential format

3. Tab sequential format

4. Word address format

5. Variable block format

G. Definition of terms

1. Bit
2. Row
3. Word
4. Block
5. Character
6. Track (channel)
7. Leading feros
8. Trailing feros
9. Parity bit

V. PART PROGRAMMING FUNDAMENTALS

A. Preparatory and miscellaneous functions

1. Preparatory functions
2. Miscellaneous functions

B. Fundamental elements of a complete program

1. Type of demensioning system

C. Type of tape format (example: THB sequential)_

D. Axis designation

1. "x" axis
2. "y" axis
3. "f" axis

E. Leading or trailing fero system

F. Miscellaneous functions available on system

1. 02 rewind code
2. 06 tool change code
3. 52 spindle down code
4. 53 spindle up code
5. 54 third axis code
6. 55 hi feed rate code
7. 56 tool inhibit code

G. Special functions available on a machine tool

1. EOB - end of block code
2. RWS - rewind stop code
3. TAB - tabe code

H. Machine set-point system (example: floating feed point system)

I. Programming steps

1. Prepare N/C coordinate drawing
2. Plan operations sequence
3. Prepare program manuscript
4. Punch tape
5. Verify tape
6. Make machine run

J. Tape preparation methods, kinds of tape punching equipment

K. Tape verification methods (types of)

(1) Friden flexowriter printout

(2) Tally system

(3) Plotter verification method

(4) machine verification method

(5) Slo-syn editor system

L. Typical control system controls

1. manual input dials

2. Manual controls

3. Tape controls

4. Positioning dials

5. Feed rate dial

6. Tool dial

7. Sequence control

8. Tape reader threading

M. Typical machine controls

1. Axis designation

2. RPM control

3. Coolant system

4. Spindle depth control

5. Machine drives and leadout system

6. Machine set-point type

a. Floating fero point

b. Fixed fero point

N. Machine set-up and operation

VI. ADVANCED PROGRAMMING CONCEPTS

A. Speed and feed rates

1. Speed (RPM) rates

2. Feed rates (inches per minutes)

B. mirror image

1. "x" axis

2. "y" axis

3. "f" axis

C. Automatic tool changers

1. Definition and application

2. Principal types and designs

D. Linear and circular interpolation

1. Linear interpolation

a. Definition - That capability of a control system to generate a straight line from one point to another point by giving the x,y, and f coordinate of the end point of the line.

b. Capability in two or three axes

2. Circular interpolation

a. Definition - That capability of a control system to generate an arc of a circle not more than 90 degrees with one block of information.

b. Capability in two axes at a time

(1) xy plane

(2) sf plane

(3) yf plane

(4) I,J, and K functions

E. Computer programming application

1. Advantages

2. Computer languages related to numerical control

Examples:

(a) APT - Automatically programmed tools

(b) AD-APT- Adaption of APT

(c) Auto spot - Automatic system for positioning tools

VII. COMPUTERIZED NUMERICAL CONTROL (CNC) AND DESCRIPTION

APPRENTICE OUTLINE - MACHINE THEORY

T-11 DIE MAKING

OBJECTIVE: To provide the student with the knowledge of tool and die design, dealing with principles, jig and fixture functions, types of jigs, fixtures, component parts, and plastic die molding methods.

I. SAFETY

II. INTRODUCTION AND PRINCIPLES

III. TOOL AND DIE

A. Layout Dies

1. Die design and construction
2. Stock utilization
3. Development of blanks
4. Estimating
5. Development of building allowances

B. Shear Blanking Punch

1. Punch-die clearances
2. Methods of shearing, brass, solder, chamfer
3. Use of hydraulic press
4. Lubricants

C. Templates

1. Layouts
2. Measuring - indicator, other methods

D. File Draft Angle in Die Cavity

1. Purpose of clearance

2. Methods filing

3. Selection of files

E. Reliveing Punch and Die Clearance

1. Determine proper clearance

2. Purpose of proper clearance

3. Methods of relieving stock

F. Major Repairs on Punch - Dies

1. Understanding function of tool

2. Trouble shooting

G. Sharpen Dies and PUnches

1. Wheel Selection

2. Wheel dressing

3. Job set up

H. Assemble and Dissemble Simple Tools

1. Nomenclature of simple tools

2. Understanding of fastening techniques

I. Set Up and Operate Compound Die in Press

1. Press operation

2. Purpose of compound

J. Tracing Malfunctions in Presswork

1. Trouble shooting

2. Function of stops pilots and automatic feeding devices

IV. Jigs and Fixtures

APPRENTICE OUTLINE - MACHINE THEORY

T-12 EYELET THEORY

OBJECTIVES: To provide the student with information which he will apply to the operation and set of eyelet forming tools and presses.

I. TYPES OF PRESSES

A. I.C.O.P. - Baird - Minster

1. Capacities
2. Advantages
3. Disadvantages
4. Auxiliary attachments

II. BLANKING OPERATION

A. Components

B. Types

C. Design

D. Clearances

III. CUPPING OPERATION

A. Components

B. Designs

C. Radius Derivation

IV. REDRAWING OPERATIONS

A. Components

B. % Reduction

C. Radius Styles

D. Clearance and bearing surfaces

V. TRANSFERRING FINGERS

A. Types

B. Designs

C. Tooling

IV. PROCESS TIMING

A. Purposes

B. Cams

C. Frictions

1. Overhead rear

2. Die bed

3. Slide

VII. CLIPPING AND PIERCING OPERATION

A. Types

B. Designs

C. Methods of Scrap Removal

1. Gravity chute

2. Air

3. Cutting horns

VIII. AUXILIARY OPERATIONS

A. Types

B. Principles

C. Components

APPRENTICE OUTLINE - MACHINE THEORY

T-13 SCREW MACHINE

OBJECTIVE: This is a survey course designed to provide the student with basic knowledge of screw machines, hand tools as applied, turret lathe-tool geometry and understanding of threads.

I. SAFETY

II. INTRODUCTION

A. History of Screw Machine

B. Familiarization of the Automatic Screw Machine Industry

C. Various types of Screw Machines

1. Single spindle

2. Multi spindle

III. MATERIAL CHARACTERISTICS

The student should be able to identify or formulate or use:

A. Types of Materials

1. Color code

2. Number system

3. Other

IV. HANDTOOLS

A. Use and Care

B. Hammers

C. Screwdrivers

D. Safety for hammers and screwdrivers

Test - Hammers and screwdrivers

E. Wrenches and their use

F. Hacksaws and their use

G. Safety using wrenches, hacksaws and power saws

Test - wrenches and saws

V. QUALITY CONTROL AND INSPECTION

The student should be able to use accurately:

A. Precision scale (British, Metric)

B. Micrometer (British, Metric)

C. Dial Test Indicator/Surface Place

D. Dial Caliper

E. Vernier Caliper

F. Protractor

G. Plug gage (go, no go)

H. Ring gage (go, no go)

I. Optical Comparator

J. Micro-finish gages (profilometer)

VI. MILITARY STANDARDS - MIL - STD - 8c

A. Definitions

B. Requirements

1. General

2. Detail

C. Dimensions

D. Tolerance and Limits

E. Notes

VII. TURRET LATHE

A. Safety

B. Orientation

1. Nomenclature

a. Types (Ram type) (Saddle type)

2. Maintenance

C. Methods of Mounting Work

D. Cutting Processes

1. Internal cuts (Hexagon turret) - Ram

a. Drilling

b. Boring

c. Reaming

d. Recessing

e. Tapping

2. External cuts (Square turret) Carriage

a. Turning

b. Facing

c. Forming

d. Threading

e. Taper

f. Cut off

E. Frictions and Lubrications

1. Ways

2. All moving parts

F. Speeds and Feeds

VIII. TOOL GEOMETRY

The student should have a basic knowledge of:

A. Simple Tool Geometry

B. Drills (types)

C. Reamers (types)

D. Form tools

1. Dovetail

2. Circular

3. Flat

E. Calculating dimensions for:

1. Dovetail tools

2. Circular tools

3. Flat tools

IX. THREADS

A. The student should have a basic understanding of:

1. Nomenclature

2. Standard tap markings

3. Classes of fits

4. Dies cut threads

5. Rolled threads

6. Checking size

APPRENTICE OUTLINE - MACHINE THEORY

T-14 MOLD MAKING

OBJECTIVE: To provide the student with the basics of mold making.

I. MOLDING METHODS

A. Compression molding

B. Transfer molding

C. Injection molding

D. Cold molding

E. Continuous extrusion

F. Molded laminations

II. MOLDING MATERIALS - USES

A. Ph nolic plastics

B. Amino plastics

C. Cellulose plastics

D. Ethyl Cellulose

E. Acrylic plastics

F. Vinyl plastics

G. Styrene plastics

H. Nylon

I. Shellac

J. Cold molded plastics

III. PLASTICS PRODUCT DESIGN

A. Moldability

B. Parting lines

C. Knockout pins

D. Pickups

E. Shrinkage

F. Dimensional tolerances

G. Warpage

H. Draft

I. Wall thickness

J. Fillets

K. Sharp corners

L. Ribs and bosses

M. Holes

N. Molded threads

O. Inserts

P. Lettering on molded products

Q Surface finishes

IV. MOLD CONSTRUCTION

A. Mold plates

B. Sprues

C. Runners

D. Gates

E. Cavities and plungers

F. Venting

G. Mold pins

H. Ejector pins

I. Return pins

J. Guide pins

K. Guide pin bushing

L. Steam lines

M. Assembly

V. MOLD MAKING MATERIALS

A. Low carbon steel

B. Medium carbon steel

C. High carbon steel

D. Alloy steel

E. Beryllium copper

F. Kirksite

G. Meehanite

H. Tombasil bronze

VI. HOBBING STEELS

A. Alloy type

VII. MOLD DESIGN -ESSENTIAL INFORMATION

A. Location of knockout pins

B. Location of parting lines

C. Will part have top or botton knockouts

D. Location of gates, if used

E. Where can pickups be placed if used

F. Where can draft be applied, and how may it be used

G. Are inserts to be molded - in or pressed -in

H. Are side inserts necessary and, if so, how may they be supported

I. Are wedges required

J. Where will wedge parting lines be located

K. What type of insert pins are to be used and how will they be held on to pins.

L. Do mold pins spot holes? Do they butt in center or do they enter the matching section of the mold:

M. Where will the tool room want radii for ease in matching the modl

N. Where will the tool room want sharp corners for low-cost construction

O. Will the cavity be hobbed of machined

P. Can and should the cavity or plunger be made in one piece

Q. Where should tolerances be shown

APPRENTICE OUTLINE - MACHINE THEORY

T-15 BORE MILL

OBJECTIVE: To provide the student with knowledge of the operation and application and use of the horizontal bore mill.

I. SAFETY

II. ORIENTATION

A. Nomenclature, types, sizes

B. Maintenance

III. METHODS OFMOUNTING WORK

A. Plain vise and swivel use

B. Angle plates and rotary tables

C. Fixtures clamped on table

D. Work clamped on table

IV. CUTTING PROCESSES

A. Spotting and drilling holes

B. Boring holes

C. Face milling

D. Recessing the face

E. Milling grooves and slots

V. SP[EEDS AND FEEDS

VI. LUBRICATION

A. Table ways

B. Saddle ways

C. Rear post slide

APPRENTICE OUTLINE - MACHINE THEORY

T-16 JIG BORER AND GRINDER

OBJECTIVE: To provide the student with the knowledge of operation and application and use of the Drill and Jig Borer.

I. SAFETY

II. DRILL JIGS

A. Finish Grind All Key Slots

1. Wheel set
2. Wheel dressing
3. Measuring techniques

B. Locate and Dowel in Place All Detail Parts

1. Purpose of dowel
2. Methods of doweling

C. Lap Drill Bushing to Size

1. Types of lapping compounds
2. Methods of lapping
3. Purpose of lapping

D. Finish Grind O.D. of Drill Bushing

1. Finishes
2. Coolants
3. Speeds and feeds
4. methods of measuring

E. Final Assembly of Drill Jig and Fitting

1. Types of jigs
2. Purpose of jigs
3. Methods of assembly
4. Inspection techniques

F. Tryout and Inspection of First Part

1. Methods of inspection
2. Purpose of inspection

III. JIG BORER

A. General Maintenance and Practice

1. Variable speeds - spindle
2. Pressurized lubrication for tables
3. Cleanliness
4. Spindle and vertical slide lubrication
5. Switches and machine handles readily accessible from one position.
6. Use "Way Lube" oil for table lubrication
7. Proper use of accessories
8. Be sure machine is properly leveled - 3 point
9. Locking mechanisms - table
10. Verticle spindle stop

B. Location Problems

1. machine conditions
2. Cleanliness
3. Clamping work to table
4. Temperature changes
5. Dimensioning
6. Stresses of material
7. Stock removal
8. Single point cutting tool
9. Screw-blacklash

C. Foundation of Accuracy

1. Basic elements
2. Flat plane
3. Surface plate (cleanliness)
4. Perpendicular
5. Cylindrical and blade type squares
6. Linear standards
7. Lead screw
8. Gage blocks
9. Angular division of the circle

D. Coordinate Locating System

1. Rectilinear movements
2. Zero lines external to work piece
3. Edge finder (use of Indicator)
4. Locating microscope
5. Relation of coordinate to machine

E. Polar Coordinates

1. Rotary table
2. Angular values
3. Pick-up points

F. Jig Borer Accessories

1. Quick change tool adapters
2. Precision vise
3. Extension parallels
4. 1" x 2" x 3" blocks ± .0001
5. Micro sine plates
6. Rotary table
7. Indicator and holder
8. Edge finder
9. Locating microscope
10. Precision drill chucks
11. Spotting tools- single lip
12. Jig borer drills - straight shanks
13. Sweeping tools for facing and rapid hole enlargement
14. End reamers - straight shanks
15. Adapter collets
16. Boring chuck - swivel block type
17. Boring chuck - dovetail offset type
18. Solid type boring bars
19. Boring bars- high speed or carbide

20. Leaf taper gages

21. Right angle - Angle plate

22. Bolts, straps, and heel rests - for clamping

23. Straightedge - attached to table

24. Standards - for vertical movement of spindle head

IV. JIG GRINDER

A. Operation

1. Methods of location

2. Lubrication of grinder

3. Operation of grinder

4. methods of set ups

5. Wheel selection

6. Head selections

7. Speeds and feeds

8. Measuring techniques

9. Use of accessories

B. Jig grind contours and angular clearances

1. Spindle set over

2. Caution in setting screws

3. Measure with indicator

4. Set up with indicator

5. Set head and stops

6. Wheel dressing

C. Jig grind Radii and to shoulders

1. Set ups
2. Purpose of stops
3. Use (extender) large holes
4. Techniques of precision grinding

RECOMMENDED TEXTS

TEXT	REFERENCE
Machine shop operations and Manufacturing Process Porter and Lascoe -Johnson - Charles Bennett Amer. Tech. Soc. -Pub. c-1979	M-1 Thru M-8
Machine Tool Technology, Repp and McCarthy, McKnight Publishing Co., Bloomington, Illinois Fourth Edition 1979 and Fifth Edition 1984	Basic
Grinding Technology- Norton Delmar Pub. Grinding Pamphlets c-1974	T6
Metallurgy Measuring and Gaging in the Machine Shop Johnson and Weeks -Amer.Tech. Soc. C-1977 *(NTMA)	T-7
Compressed Air Handbook by Rollins	T8
Machine Shop Operations Manual for the particular and Set-ups Porter and Lascoe Amer. Tech. Soc. c-1973	T9
Machine Set-ups N/C Instruction Course Porter and Lascoe - Amer. Tech. Soc., Merit Machinery Inc. c- 1973 Pittsburg, Pa.	T10
Basic Diemaking Advanced Diemaking Ostergarrd, (NTMA) c-1967	T11
Tool Engineer's Handbook Amer. Soc. of Tool Eng. McGraw-Hill Pub. c-1949	T12
Manual for the particular machine (see separate list)	T13

Recommended Texts (Continued)

TEXT	REFERENCE
Moldmaking and Die Cast Dies for Metal working Trainees Klutz NTMA c 1978	T-14
Holes Contours & Surface, Moore Spec. Tool c-1955	T-15 & T16
Basic Jig & Fixtures Making for Metalworking Trainees Herbert Harig c-1978	T-17
Interpreting Engineering Drwngs. Basic Blueprint Reading by Jensen & Hines Olivo Delmar c-1978	B-1M - B4M

Recommended Texts (Continued)

TEXT	REFERENCE
Screw Machine Publications:	T-13
c-1973	Swiss Section
c-1978	On the Job Training for Screw Machine Personnel
c-1967	Trouble Shooting Machine Problems
c-1963	Training Curriculum Multiple Spindle
c-1976	Multiple Spindle Modular Training Program
c-1968	Brown & Sharp Section
c-1967	On the Job Instruction Manual for Screw Machine Operators and Set-up Men
c-1968	Realistic Cost Estimating

APPRENTICE OUTLINE MACHINE TRADES THEORY

COURSE DESCRIPTIONS

T-1 Basic Handtooks - This course is designed to provide the student with the proper use of hand tools and measuring instruments. Safety is covered as applied to the machine shop.

T-2 Lathe - This course is designed to provide the student with the knowledge of the lathe, its applications, uses, and threads and tapers.

T-3 Milling - This course provides the student with information on types of milling machines, uses, set-ups, uses of various attachments to include dividing head and rotary table.

T-4 Drills, Saws, Shaper - This course provides the student with the knowledge of cutting tools (single point tool bit, cutters, reamers and counterbores) and drill press, cut-off saws and basic shaper.

T-5 Heat Treatment and Metallurgy - This course is designed to provide the student with the knowledge of materials, processes which change the physical properties of metals.

T-6 Grinding - This course provides the student with the knowledge of removal of metal with abrasives. It describes the uses of various types of grinders used in a machine shop.

T-7 Quality Control - This course enables job processing without error. Various methods and inspection techniques are covered in detail.

T-8 Hydraulics and Pneumatics - This course provides a basic working knowledge of air and fluid mechanics, their applications, components. Use of schematics is covered (interpretations).

T-9 Electro - Discharge Machining - This course provides the student with the basic principles of EDM machining. The types of machines are discussed. Electrode materials and machining gap is covered along with basic circuits.

T-10 Numerical Control - This course provides the student with a basic knowledge of numerical control machines, their principles, applications and method of programming.

T-11 Die Making - This course provides the student with a basic knowledge of die design. Various components of a die set are discussed in detail. The student will be required to sketch the plans for a die layout.

T-12 Eyelet - This course provides the student with the information necessary for the operation and set-up of eyelet forming tools and presses.

T-13 Screw Machine - This course provides the student with a knowledge of screw machines, their set-ups, tool geometry, understanding of cams and routine maintenance as applied to the machine operator.

T-14 Moldmaking - This course provides the student with a basic knowledge of mold construction, mold making materials. Essential information such as draft, gates and inserts are discussed. The student will sketch the plans for a moldmaking unit.

T-15 Bore Mill - This course is designed to provide the student with knowledge of the horizontal bore mill and its applications and uses.

T-16 Jig Borere and Grinder - This course is designed to provide the student with the knowledge of precision hole location and finishing. Jig borer and Jig Grinder operations and applications are covered.

MACHINE TOOL APPRENTICE MATH

COURSE DESCRIPTION

M-1 This math mod requires the apprentice to be proficient with factions, decimals and percentages as applied to the machine trades.

M-2 This math mod requires the apprentice to be proficient with weights, units of measures, measurements, powers, roots, ratio and proportion as applied to the machine trade.

M-3 This math mod contains areas of circles, triangles and the various geometric relationships of these figures.

M-4 This math mod places heavy emphasis on cubic measurements. Use of volume formulas dominates this mod.

M-5 This math mod includes the use of graphs, charts and geometric constructions. Problems directly applied to the machine shop challenge the student.

M-6 This math mod contains practical problems involving right triangle trigonometry and the use of tables.

M-7 This math mod contains shop problems involving oblique triangles. The use of the Cosine and Sine Law formulas are heavily stressed.

M-8 This math mod contains advanced machine shop problems. The apprentice has to rely heavily on his/her knowledge of trigonemetry and geometry. Many of these problems are directly taken from local industrial design problems.

MACHINE TOOL APPRENTICE BLUEPRINT

READING COURSE DESCRIPTION

B-1 M Basic blueprint reading - This course provides the basis for reading blue prints, beginning with the "Alphabet of lines". It allows for some sketching and/or drawing of Isometric, Oblique, or Othographic Projections. It also covers reading prints involving common views, surface finish, threads, and sections (full, removed, and revolved).

B-2 M This course is an extension of the above covering tabular dimensioning, SAE steel numbering system, dovetails, and auxiliary views.

B-3 M This course extends into true relationships, broken sections, assembly drawings, dual dimensioning, partial views, and springs. It also shows ISO standards.

B-4 M This advanced course covers such things as gears, cams, gear trains and/or actual plant prints if available.